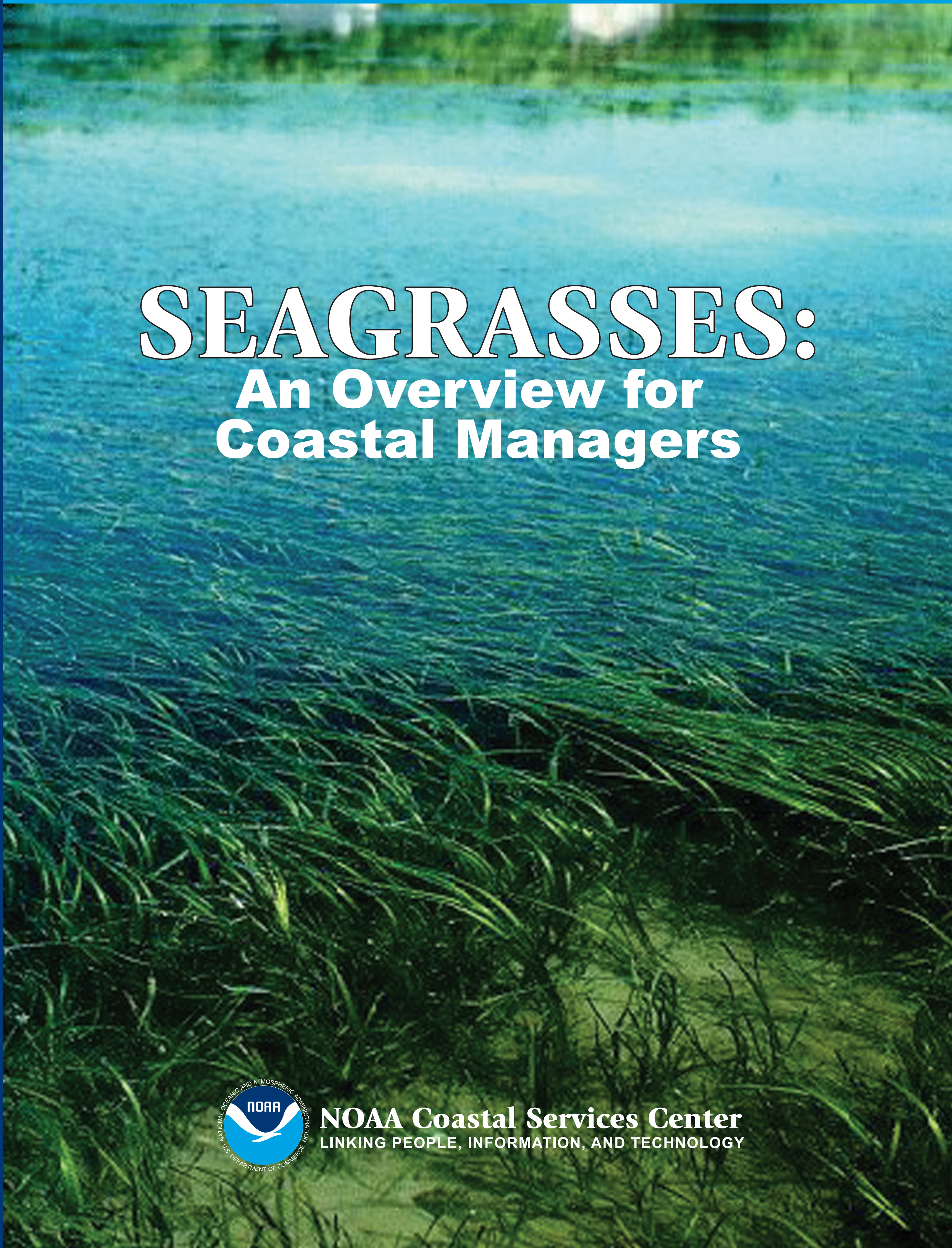

SEAGRASSES:
An Overview for Coastal Managers

NOAA Coastal Services Center
LINKING PEOPLE, INFORMATION, AND TECHNOLOGY

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On cover: Eelgrass (*Zostera marina*) meadow in New Hampshire. Image provided by Fred Short.

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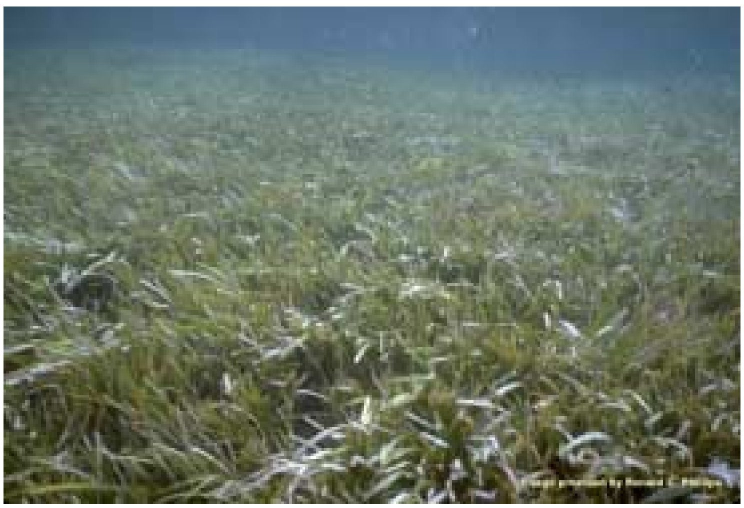
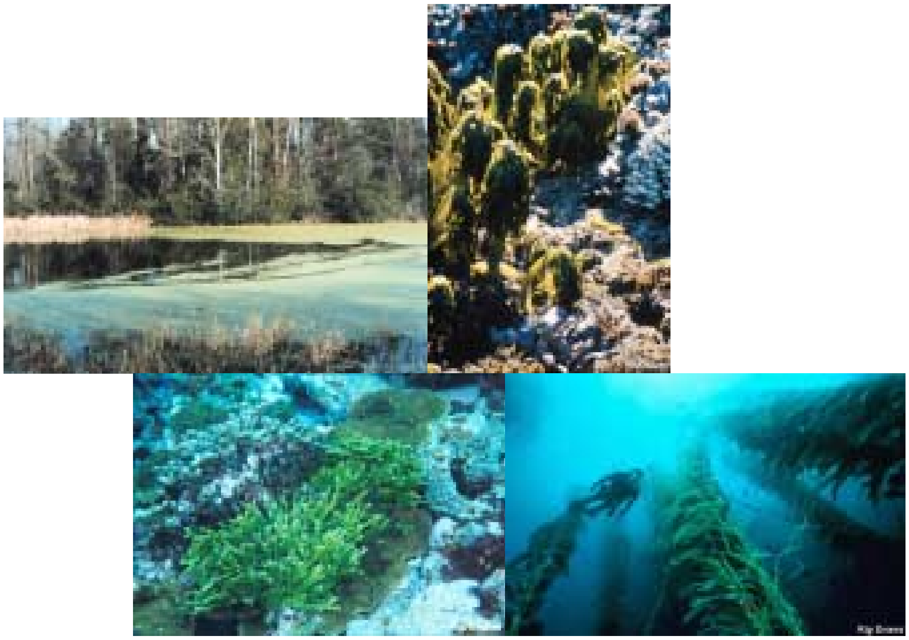
Introduction

More than fifty species of seagrasses inhabit the marine and estuarine waters of the Earth. Seagrass meadows may be composed of one or many species of seagrasses, and support hundreds to thousands of species in shallow waters (review by Zieman 1982). Seagrasses provide many services that are essential to marine and estuarine ecosystems, such as: (1) primary productivity, (2) food web interactions, (3) habitat and shelter, (4) nutrient cycling, and (5) habitat stabilization (adapted from review by Zieman 1982). Many shallow marine communities are dependent upon the presence of seagrasses; without this vegetation, the entire associated community could disappear or drastically change.



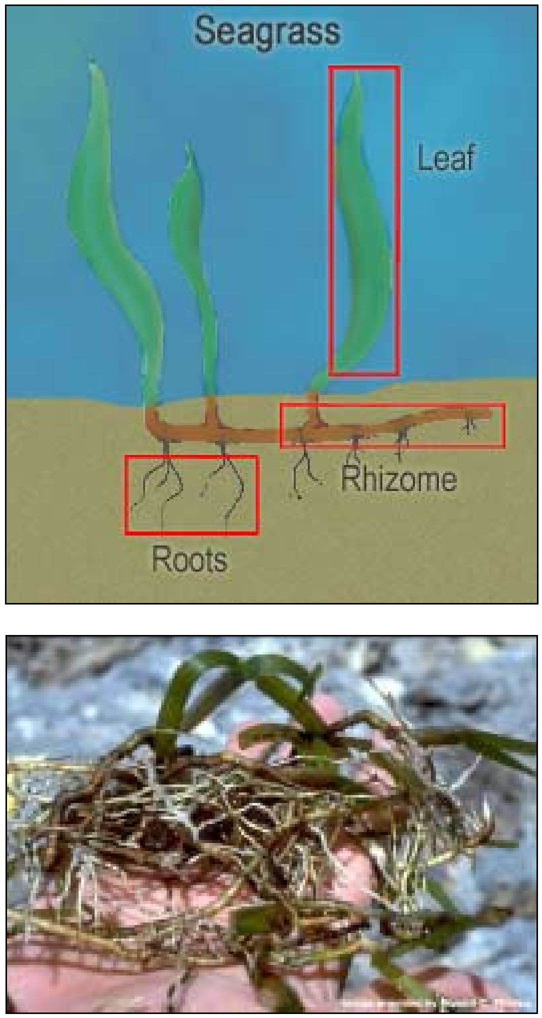
Seagrass beds often grow in monospecific meadows (composed of a single species of seagrass), that provide food and habitat to a wide variety of marine flora and fauna.

Often confused with marine algae or “seaweed,” seagrasses are a unique type of plant. Unlike land plants, seagrasses and marine macroalgae (not single celled) grow underwater and do not have to withstand the strong effects of gravity on land. Therefore, rather than having rigid and supportive trunks and branches, seagrasses and algae use the buoyancy of water for support while remaining flexible to the wave action. While seagrasses and marine macroalgae grow submerged and provide dissolved oxygen to organisms in the water, seagrasses are very different from algae and more similar to terrestrial grasses. Seagrasses are complex plants with differentiated tissues that are specialized for performing specific functions, such as a vascular system to transport gases and nutrients from the photosynthesizing leaves to the roots.



Most people are familiar with the appearance of algae growing on the surface of water (far left). However, algae grow in many physical forms, which enable the plants to inhabit and thrive in a wide range of environments, from the tropics to the polar regions (Lerman 1986). Clockwise from left, algae growing on a pond, sea palms, algae growing on rocks, and giant kelp.

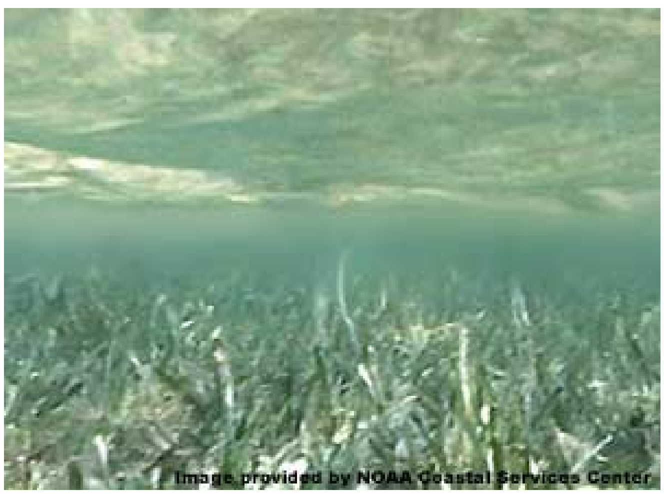
Seagrasses are complex plants with roots that anchor the plants and absorb nutrients from the surrounding sediments. These roots intertwine and hold the sediments from washing away with the currents. Seagrasses photosynthesize and release dissolved oxygen into the water column. Wide ranges of organisms require the dissolved oxygen produced by seagrass for respiration and decomposition. In order to produce this oxygen, the plants depend upon sunlight for photosynthesis. The amount of sunlight that penetrates the water and reaches the seagrass plants restricts the depth at which seagrasses grow. As a result, seagrasses are typically limited to clear or shallow waters. Unfortunately for seagrasses, these near shore environments are typically close to coastal developments and human activity that may inadvertently threaten the meadows by reducing water quality and clarity.



Seagrasses are complex vascular plants with roots, rhizomes, and leaves.

Growing in shallow coastal waters, seagrass species worldwide are threatened by population growth and development along the coasts. Coastal development may increase nutrient and sediment run-off and result in increased water turbidity (cloudiness), while dredging and boating may damage and kill seagrasses. Continuously stressed seagrass meadows eventually lose the ability to compete with other marine species for sunlight or habitat. Changes that arise from damage and stress to seagrass meadows are sometimes subtle and difficult to discern; such as gradual reductions in crustaceans, finfish and shellfish population and increases in alga blooms. These seemingly small changes can quickly escalate into large irreversible transformations that result in the loss of important fishery species or habitat.

The life history of seagrasses increases the difficulty of understanding and protecting seagrass meadows. Not only do seagrasses grow underwater (out-of-sight, out-of-mind), the meadows are naturally dynamic and may change significantly within a year. Seagrass plants that produce seeds at the end of each growing season and die-back are termed 'annuals.' Vast, lush meadows of annual plants during the summer may appear completely decimated during the winter. It is extremely difficult to assess the next meadow from dormant seeds buried in the bare sediments. In contrast, 'perennial' plants survive from year to year, but during the winter greatly reduce the above ground vegetation (leaves and stems; Phillips and Meñez 1988). The plants lie dormant under the sediments as roots and rhizomes. For either species, plants studied during the growing season would have much higher biomass and be easier to detect than plants studied during to the winter.



Seagrasses grow in shallow coastal waters. The depth at which seagrass grows is dependent upon water clarity and species.

Although seagrasses are globally distributed, this paper will focus on species that occur along the coast of the United States (including U.S. territories in the Caribbean). U.S. federal laws have been in place for years to protect seagrasses and near shore shallow water habitats. However, many coastal communities are just beginning to understand the importance of protecting and preserving seagrass meadows.

Seagrass Value

An ecosystem is a term used to describe the interactions between the physical and chemical (abiotic) and biological (biotic) environments (Ricklefs 1993). Within an ecosystem, each species typically contributes a service or function to maintain the system. This contribution may be as a producer (for example, seagrass), predator (shark), prey (fish), herbivore (manatee), or detrivore (decomposer; bacteria). In a marine or estuarine ecosystem, seagrass meadows provide not only provide dissolved oxygen, they serve as food resources, habitat, shelter, baffle wave energy, and stabilize sediments. Seagrasses are integral to the survival of many different animals directly or indirectly and an ecosystem that loses its seagrass habitats will be greatly impaired (review by Zieman and Zieman 1989).

Primary Productivity

In both marine and terrestrial environments, the origin of most transferable energy is primary productivity. Photosynthetic tissues in the leaves capture sunlight and use the energy to convert carbon dioxide into sugar and dissolved oxygen. Dissolved oxygen is required for respiration (breathing) and decomposition. Animals that consume seagrasses digest the sugars and incorporate the energy, these animals may serve as prey for predators. As a result, a wide range of organisms may be directly or indirectly dependent upon seagrasses for food or oxygen (review by Zieman and Zieman 1989).

Manatees are large mammalian consumers of seagrasses. This photograph is of an Antillean manatee on a seagrass bed in Puerto Rico.

Seagrass blades, stems, and rhizomes (underground stems) are the primary food resource of some large marine animals, such as turtles and manatees (review by Zieman 1982). In addition, some species of marine waterfowl (for example the black brant, bufflehead, and Canada goose) are dependent upon seagrasses as a food resource.

The loss of seagrasses has been associated with significant declines of popular game birds that consume seagrasses and other submerged aquatic vegetation (SAV) as primary food resources. The die-off of eelgrass meadows in the Pacific Northwest (1930's and 1940's) is implicated as a contributor to the major shift in the migratory patterns of the black brant (Moffitt 1941). This waterfowl historically over-wintered in the Pacific Northwest, and presently approximately 80% over-winter in Mexico (Derksen and Ward 1993). Similarly, the loss of SAV in the Chesapeake Bay, in combination with other human pressures (such as over-hunting, habitat loss and development), has caused a drastic change in population sizes and foraging of SAV consuming ducks. These once plentiful waterfowl populations have drastically declined (redhead duck), while others have completely shifted food resources in order to survive (canvasback, Canada goose). Those unable to adapt to the changes are still in decline.

Epiphytes grow on the surface of seagrass leaves and many crustaceans, finfish and shellfish graze on these microscopic organisms.

In addition to being a primary food resource, seagrasses are intimately associated with another important food resource in near shore environments. These food resources, commonly referred to as epiphytes, are composed of microscopic photosynthesizing organisms that attach to seagrass leaves and they may be involved in nutrient exchange with the plants (review by Zieman 1982, Phillips and Meñez 1988). Epiphytes are an important food resource for many economically important species of crustaceans, finfish and shellfish. Fish feeding on or in seagrass meadows as adults or juveniles, include recreational and commercially valuable snapper, grouper, bonefish, barracuda, sea trout, tarpon, sea bass, shrimp, crabs, lobsters, scallops, sponges, and mollusks (Thorhaug 1990).

Habitat and Shelter

In addition to providing food resources to economically valuable fishery species, seagrass meadows also provide essential fish habitat. Shallow marine waters may be constantly battered and scoured by waves and tides, a potentially harsh and barren landscape for juvenile or small crustaceans, finfish and shellfish. However, waters with seagrass meadows experience the baffling of wave energy by the leaves and are provided a textured and varied landscape on the shallow seafloor. The leaves of seagrasses help conceal small finfish, shellfish and other invertebrates, while physically obstructing predatory fish, birds, and mammals from efficient and effective foraging. The habitat created by seagrasses are utilized by many species of crustaceans, finfish and shellfish which may be spawned in the beds or migrate to the beds at some life stage, hence the nickname nurseries (review by Thayer et al. 1984).

Economically valuable finfish (such as the flounder seen here) seek refuge from predators and graze for food in seagrass beds.

The physical structures of seagrass rhizomes and leaves also provide critical habitat to many benthic organisms. Growing rhizomes intertwine and form mats that hinder predators from digging for buried prey. In addition, sponges and commercially valuable mollusk species, scallops and oysters, depend on seagrass leaves for attachment sites.

Echinoderms, such as sand dollars seen here, may burrow in the sand within a seagrass meadow to gain protection from predators.

Nutrient Cycling

Seagrasses cycle nutrients in marine ecosystems through a number of natural processes (Peterson and Lubchenco 1997). Global nutrient cycling by seagrass meadows was estimated by Costanza et al. (1997) at a value of $19,002 per hectare per year.

In shallow waters, the growth of seagrasses may be limited by the amount of usable nitrogen in the sediments (Phillips and Meñez 1988). Often large amounts of nitrogen are in the water column but are in a form that seagrasses and other organisms can not use. Some epiphyte species have symbiotic (mutually beneficial) relationships with seagrasses. Seagrasses provide epiphytes a site for attachment, which is critical to epiphyte survival, while the epiphytes convert nitrogen (nitrogen fixing) to a form that is usable by seagrasses (McRoy and Williams-Cowper 1978, review by Zieman 1982, Phillips and Meñez 1988). As seagrasses die, decomposers break down the tissues and the nitrogen is released back to the shallow water environment.

Epiphytes are an important food source for grazing species. Such as the conch seen here.

The physical structure of seagrass meadows also assists nutrient cycling by catching, holding, and supplying detrital material to the decomposers. Decomposition is essential for complete nutrient cycling. Organic material (dead leaves, twigs, animals) in the water are potential sources of carbon, nitrogen and other nutrients. However, the materials must be broken down into smaller pieces prior to utilization. The process occurs through the mechanical breakdown of material (chewing, tearing) and microbial (bacteria and protist) activity, which releases bound nutrients or converts them directly into biomass. Seagrasses promote nutrient cycling by trapping the detrital matter for a large variety of organisms, including scavenger birds and mammals, crabs, and microscopic bacteria that thrive in seagrass meadows.

Sedimentation

Seagrass leaves baffle wave energy while roots and rhizomes trap and hold the sediments from the scouring tides. Seagrasses act as natural buffers by protecting the benthos from the scouring effects of tide energy (Lerman 1985). Roots, rhizomes, and leaves maintain and stabilize the sediments found in intertidal zones. Seagrass leaves attenuate wave energy and decrease water velocity. The leaves trap sediments (sand

and mud) that are carried by the currents and thus aid the process of sedimentation (Phillips and Meñez 1988). As a result, seagrasses may help prevent erosion along the shoreline.

This image illustrates how the roots and rhizomes of *Halodule wrightii* intertwine and hold the sediments.

Threats to Seagrasses

Seagrass meadows are dynamic habitats that change in space and time (review by Zieman and Zieman 1989). Seagrasses are not mobile organisms; meaning individual plants cannot escape the local environment if the habitat becomes unsuitable. When seagrasses are stressed they are forced to tolerate the changes, adapt to the changes, or succumb to the changes (die). These stresses may arise from abiotic (chemical and physical) or biotic (biological) sources, and may be natural stresses or those that are influenced by human activity.

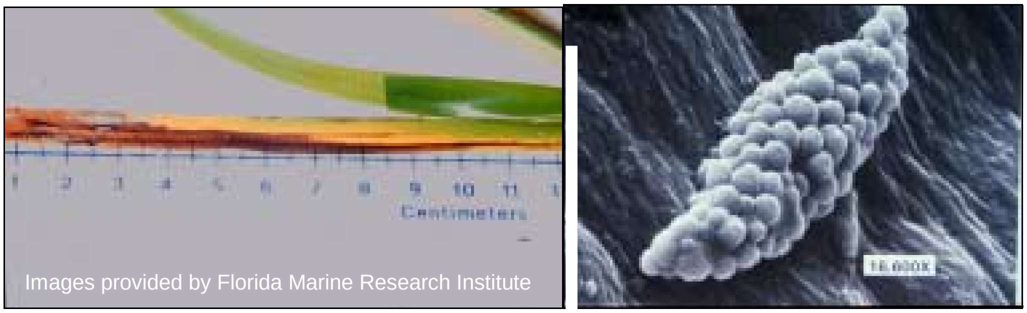
A healthy seagrass meadow on the left greatly contrasts with the unhealthy meadow on the right.

Seagrasses respond differently to stress and damage. Damaged seagrass leaves and stems (above ground vegetation) typically recovers naturally over a few weeks to a few years, depending on the extent of damage and the species of seagrass (some species grow more slowly; review by Zieman et al. 1984). However, damage to rhizomes decreases the ability of seagrasses to produce new leaves and stems structures. Consequently, rhizome damage greatly reduces the chances of meadow recovery, and depending on the extent of the damage, some species may never recover (review by Zieman et al. 1984). For more discussion of seagrass loss and restoration see Fonseca et al. (1998).

Natural Threats

Wasting Disease

In the early 1930s, a species of seagrass common to temperate North America, eelgrass (*Zostera marina*), disappeared from a large portion of its range. The die-off event is commonly attributed to the “wasting disease.” Within two years, 90 percent of all eelgrass populations in the North Atlantic (from Canada to North Carolina) had disappeared (Rasmussen 1977, review by Thayer et al. 1984). The disease similarly ravished coastal Europe’s eelgrass populations.



The image on the left is a close-up view of a lesion caused by *Labyrinthula*, which is magnified 16,600 times on the right.

The exact cause of the "wasting disease" is unknown, but there is evidence of historical seagrass die-offs (Rasmussen 1977). Originally, the causative agent was hypothesized to be a marine slime mold (*Labyrinthula*). *Labyrinthula* invades weak or stressed leaves, causing brown lesions (see above) that reduce the ability of the plant to photosynthesize and may eventually lead to death. However, the fungus is known to be present in many unaffected seagrass meadows (Rasmussen 1977). The confusion has prompted the exploration of many potential causes, including the possibility that warmer ocean temperatures prompt and/or contribute to the massive die-offs (Rasmussen 1977). Regardless of the cause, the "wasting disease" outbreak of the 1930s brought global attention to the importance and value of seagrass, as economically valuable crustaceans, finfish and shellfish populations declined, migratory waterfowl declined, and beaches and shorelines significantly eroded (Rasmussen 1977, review by Thayer et. al 1984).

Storms

Coastal areas may be impacted by storms on a regular to sporadic level. These storms may bring increased duration and intensity of wave energy, resulting in breaking off of vegetative structures of seagrass meadows. Damage to seagrass leaves are recoverable within months to years depending on plant species. In addition, the wave action can stir of sediments and increased run-off which may result in reduced water quality and turbidity (see discussion below on water quality). Storms with a lot of rain may decrease the salinity of the water to levels in tolerable by seagrass plants.

Horseshoe crabs disturb seagrass meadows by digging in the grass and sediments.

Animals

A variety of marine and estuarine species physically disturb seagrass meadows. Fish, rays, crabs, and skates do not consume seagrass, but rest and forage in the meadows, disturbing and damaging vegetation (Zieman 1982). These animals often tear up small portions of the beds looking for buried shellfish or consuming seagrass (as is the case with manatees). These natural feeding activities reduce and remove seagrasses, and may increase the susceptibility of seagrass meadows to blowouts. Blowouts are open sand or mud areas within otherwise continuous seagrass beds that may be more vulnerable to localized erosion.

Marine herbivores (animals that eat plants) may threaten seagrass populations by overgrazing, and thus negatively impact seagrass meadows. Late in the summer of 1997, a massive population cluster of sea urchins along coastal Florida overgrazed the seagrass, defoliating miles of seagrass meadows. Although a natural consumer of seagrass, the urchins were experiencing a population boom that significantly damaged the seagrass meadows. In addition, non-native or invasive species may be blamed with further damaging seagrass meadows. The mute swan of the Chesapeake Bay is a consumer of SAV but not native to the area.

Human Induced Threats

Water Quality

Many factors influence water quality. Nutrient loading and suspended sediments are two common causes of water quality decline and are influenced by human activity. Both nutrients and sediments may enter the water through point source and non-point source pollution. Point source pollution is from a direct source, i.e. a sewage effluent pipe. Typically, it is easy to pinpoint and identify point source pollution. However, non-point source pollution is from a wide variety of sources and may be the result of runoff from parking lots, golf courses, farms, construction sites and other development.

Nitrogen and phosphorus are naturally found in water and are essential for plant growth. However, phosphorus and nitrogen are found in high levels in fertilizer, sewage treatment plants, and animal wastes – all common contributors to eutrophication (nutrient loading). When these nutrients occur in excess they may stimulate and promote the growth of large populations of suspended algae and phytoplankton. These algae cloud the water and reduce the amount of sunlight able to penetrate to the bottom. As seagrass photosynthesis is reduced, the plants become unable to grow and survive. In addition, excessive nutrients in the water column may also disrupt the balance between epiphytes and seagrasses further reducing the ability of the plants to photosynthesize. Finally, as these algae die and are decomposed, an oxygen deficit may result as oxygen is consumed for decomposition.

Development and forestry along the coast may increase the amount of organic material and sediment run-off. Excess sediments and particles in the water contribute to reductions in water quality and further threaten seagrass survival. Sediments may also be resuspended in the water column as the seagrass health is compromised and the amount of roots and rhizomes are reduced.

Dredging

Dredging involves digging and removing sediments to maintain or increase the depth of shipping channels. U.S. laws currently protect or mitigate the effects of dredging in seagrass areas. However, dredging near seagrass meadows may have significant negative impacts by increasing the turbidity and suspended sediments in the water, (Phillips 1984). The physical properties of the dredged areas, such as bottom morphology (bathymetry), may cause changes in the velocity or direction of currents – a potential threat to nearby seagrass meadows (Phillips 1984).

Prop Scars

Recreational and commercial boating may have significant impacts to seagrass meadows through accidental grounding or propeller strikes from watercraft in shallow waters. Often a result of negligent or inexperienced boating, prop scars occur when the boat is in water that is shallower than the recommended draft of the boat. Propellers do not just damage seagrass leaves; they often dig up the seafloor and damage or destroy the entire root and rhizome of the plant. In addition, the digging typically results in a continuous seagrass-devoid line in the meadow as the boat is moving. This type of damage may take years for the plants to recover if they recover at all.

Prop scars create discontinuous and fragmented seagrass beds.

Small-scale prop scars have large impacts on seagrass habitats. Initially, the habitat becomes fragmented by the continuous voids; this effect is enhanced if the meadow has numerous scars or if the meadow has sparse seagrass coverage. The remaining seagrasses have increased vulnerability to erosion and further damage. Over time, the scars may coalesce (join) to form large voids within seagrass meadows (Sargent et al. 1995). The Florida Marine Research Institute found approximately 7% (or 61,752 hectares) of seagrasses in coastal Florida Bay were loss due to scarring alone (Sargent et al. 1995).

Protecting Seagrass

Seagrasses are critical to near shore environments and should be valued as such by coastal communities. Unfortunately, protecting this seagrass has been challenging, as changes to the beds and the outcomes of the changes may be subtle or difficult to detect. Difficult as it may be, if the world's fisheries and the health of the coast are to be maintained or improved, then seagrasses must be recognized and quantified. The first step in managing these meadows is to map the seagrass and develop base line data to begin understanding the valuable resource. Mapping seagrass is no easy task, it takes planning, money and training. The costs and energy required for mapping may seem extensive, but the costs of having an unhealthy and unproductive near shore environments may have global implications for fisheries.

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http://shrimp.bea.nmfs.gov/library/digital.html

Florida Sea Urchin Information

http//:monroe.ifas.ufl.edu/flbayw1.htm

Chesapeake Bay Waterfowl and SAV Information

http://www.fws.gov/r5cbfo/savpage.htm

http://www.chesapeakebay.net/baybio.htm